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Atlantic salmon return and spawner estimates for Labrador

Estimations des retours et des reproducteurs de saumon atlantique au Labrador

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ABSTRACT

In this paper, estimates of 1-sea winter (1SW) and 2-sea winter (2SW) returns to rivers and spawners for Labrador salmon stocks are presented for the years 1969-2008. Estimates for 2008 are preliminary. The estimates of Labrador returns were derived by three techniques for periods of 1969-1997, 1998-2001 and 2002-2008. The first technique utilized exploitation rates that were derived from a tagging study at Sand Hill River, Labrador in 1970-1973 applied to commercial salmon catches in the years 1969-1997 and corrected for non-Labrador origin salmon in the fishery. The second technique utilized exploitation rates applied to angling catches to derive returns for the years 1998-2001. The third technique utilized counts at four enumeration facilities in Labrador adjusted for drainage area to derive returns for all Labrador rivers for the years 2002 to present. Spawners in all years were determined as the returns to rivers minus the landings in angling fisheries plus an adjustment for loses due to hooked-and-released fish. The mid-point of the estimated returns (201,069) of 1SW salmon to Labrador rivers in 2008 is 5% higher than in 2007. The mid-point (17,785) of the estimated 2SW returns to Labrador rivers in 2008 was 19% higher than in 2007 and 38% higher than the recent 5-year average of 12,932. The mid-point of the estimated numbers of 2SW spawners (17,559) was 38% above the previous year and was 50% of the total 2SW conservation requirement for Labrador. The 2SW conservation requirement has only been exceeded once (1998) since 1971. The mid-point of the estimated numbers of 1SW spawners (198,916) was 5% higher than estimated for 2007. The number of recruits has steadily declined from higher levels in the early 1970s to present low levels in spite of the closure of the commercial fishery. 1SW salmon spawners are well above conservation requirements while those of large and 2SW salmon remain well below.

RÉSUMÉ

Dans la présente étude, les estimations des retours des petits et des gros saumons dans les rivières ainsi que des reproducteurs pour les stocks de saumons au Labrador sont présentées pour les années 1969 à 2008. Les estimations de 2008 sont préliminaires. Les estimations des retours au Labrador proviennent de trois méthodes pour les périodes de 1969 à 1997, de 1998 à 2001 et de 2002 à 2008. Dans la première méthode, on a utilisé les taux d'exploitation provenant d'une expérience de marquage dans la rivière Sand Hill (Labrador) dans la période 1970-1973 qui ont été appliqués aux prises commerciales de saumons dans les années 1969 à 1997 et corrigés pour tenir compte des saumons ne provenant pas du Labrador dans les pêches. Dans la deuxième méthode, on a utilisé les taux d'exploitation appliqués aux prises de pêche sportive pour obtenir les retours pour les années 1998 à 2001. Dans la troisième méthode, on a utilisé les nombres de saumons obtenus à partir de quatre installations de dénombrement au Labrador, rajustés en fonction de la superficie du bassin hydrologique afin d'obtenir les retours dans toutes les rivières du Labrador de 2002 jusqu'à aujourd'hui. Pour toutes les années, le nombre de reproducteurs était déterminé comme étant les retours dans les rivières moins les débarquements des pêcheurs sportifs, plus un rajustement pour les pertes attribuables aux saumons capturés puis remis à l'eau. Le point milieu des retours estimés (201 069) de saumons unibermarins dans les rivières du Labrador en 2008 est 5 % plus élevé qu'en 2007. Le point milieu (17 785) des retours estimés de saumons dibermarins dans les rivières du Labrador en 2008 était 19 % plus élevé qu'en 2007 et 38 % plus élevé que la moyenne récente sur cinq ans (12 932). Le point milieu du nombre estimé de reproducteurs parmi les saumons dibermarins (17 559) était de 38 % supérieur à l'année précédente et représentait 50 % des besoins totaux de conservation des saumons dibermarins pour le Labrador. Le niveau du besoin de conservation des saumons dibermarins a été dépassé une seule fois (en 1998) depuis 1971. Le point milieu du nombre estimé de petits reproducteurs (198 916) était 5 % plus élevé que lorsqu'il a été estimé en 2007. Le nombre de recrues a diminué de façon constante par rapport aux niveaux élevés au début des années 1970 pour atteindre de faibles niveaux, en dépit de la fermeture de la pêche commerciale. Le nombre de reproducteurs parmi les petits saumons est bien au-delà des besoins de conservation, tandis que les impératifs pour les gros saumons et les saumons dibermarins demeurent bien inférieurs.

INTRODUCTION

A time series of estimates of prefishery abundance (PFA) of North American non-maturing salmon has been used since 1993 by the ICES North Atlantic Salmon Working Group (NASWG) to provide advice on catch levels for commercial and recreational fisheries in North America and the commercial fishery at Greenland (Anon. 1998). PFA which refers to the number of maturing 1SW (grilse) and non-maturing 1SW salmon prior to fisheries exploiting them is estimated by summing returns to freshwater for six major geographical areas comprising all of the North American salmon producing rivers including those of Labrador. The six major geographic areas are: Labrador, insular Newfoundland, Quebec, Scotia-Fundy, Gulf of St. Lawrence and USA. Commercial catches in mixed-stock fisheries in North America and North American origin salmon caught at west Greenland were added to the estimates of returns to freshwater that when corrected for natural mortality provided estimates of the total number of North American salmon. Estimates were made separately for maturing 1SW salmon (potential grilse) and non-maturing 1SW salmon (potential 2SW salmon). In order to maintain PFA estimates in the year of the Greenland fishery, the PFAs for the non-maturing component were lagged by one year which also places the maturing component in the same relative year.

The purpose of this paper is to document estimates of returns and spawners for Labrador, 1969-2008. This paper was prepared for a DFO held pre-COSEWIC review conducted in February, 2009 in Halifax, NS.

METHODS

LABRADOR (SFAS 1, 2 AND 14B)

Angling and Commercial Fisheries Data

The basis of estimates of 2SW and 1SW salmon returns and spawners for Labrador are catch data from angling and commercial fisheries. Catch and effort data from the angling fishery were collected by Department of Fisheries and Oceans (DFO) enforcement staff in conjunction with angling reports submitted by fishing camp operators and processed by DFO Science Branch personnel. Commercial catch data were collected by DFO enforcement staff from fish plant landing slips and processed by DFO Statistics and Informatics Branch personnel. Procedures for the collection and compilation of commercial and angling fishery data are described in Ash and O'Connell (1987) for fishery years 1974-1996. For years 1969-1974, commercial catch data came from Anon. (1978). In 1997, the angling catch statistics were converted to a licence stub system (O'Connell et al. 1998) which continues to present.

Total Returns and Spawners for Labrador (SFA 1, 2 and 14B), 1969-1997

For Labrador stocks, it was thought inappropriate to develop total recruits from angling catches and exploitation rates similar to techniques used for insular Newfoundland rivers. The problem with using angling catches to derive returns for Labrador is that until 1994 there were no estimates of exploitation rates available other than for the salmon population of Sand Hill River and these were 20 years out of date. Also, because Labrador coastal rivers are isolated the exploitation rates are low and highly variable depending on the presence of an outfitting camp and its success in attracting guests as well as the nearness of local communities. Thus, exploitation rates would depend and vary from one year to the next on the success of angling

camps in attracting anglers and may not be applicable to other Labrador rivers. Also, many rivers in Labrador have no angling fishery in particular those of Lake Melville and the smaller coastal rivers. Thus, all estimates of returns and spawners were based on commercial catches as the only source available of usable continuous time series of data.

The general approach is to use exploitation rates to convert commercial catches of small and large salmon in Labrador to the total population prior to the commercial fishery. River returns and spawners were estimated by subtracting from these populations, the commercial catch and accounting for non-Labrador origin salmon. The estimated number of Labrador origin large returns (LR) is calculated as:

(1) $LR = (CC*PL) / \mu$

where,

PL = proportion Labrador origin
CC = commercial catch
μ = exploitation rate

The estimated number of Labrador origin small returns (SR) is determined from equation (1) but using commercial catches of small salmon.

Parameter values for sea age and proportion of salmon of Labrador origin came from the sampling program in the commercial fishery, 1974-1991 (Tables 1 and 2). Even though the commercial fishery continued in Labrador up to 1997, the sampling program was dropped in Labrador at the same time as it was in Newfoundland with the closure of the Newfoundland commercial fishery in 1992. In 1997, commercial sampling resumed with samples being collected throughout the fishery at Makkovik and Rigolet in SFA 1 and Cartwright and St. Lewis (Fox Harbour) in SFA 2. River age distribution of commercial samples of small and large salmon from Labrador have been found to consist, on average, of about 75-80% river age 4 and older in SFAs 1 and 2. The commercial samples came from commercial catches sampled in Labrador at several sites along the Labrador coast including Square Islands (SFA 2) and at Nain (SFA 1) (Anon. 1993b). In total, 46,320 salmon were sampled for scales and aged. Labrador salmon stocks are thought to be about 70% of the total production of 4 and older river age salmon in Canada with the other 30% coming from northern Quebec. Thus, when non-Labrador salmon are factored in at 30% applied to the river age distribution then 60-80% of the commercial harvest of small and large salmon (PL) in Labrador are of Labrador origin (Anon. 1993b). In 1997, in SFA 1, based on the results from the sampling program in that year, the percentage of the commercial catch that was Labrador origin was for large salmon 68% (95% C.I. 64.3-72.5%); whereas for small salmon it was 39% (95% C.I. 35.6%-41.6%). In 1997, in SFA 2, the percentage of the commercial catch that was Labrador origin was for large salmon 92% (95% C.I. 88.4-95.2%); whereas for small salmon it was 80% (95% C.I. 74.8%-85.0%).

Exploitation rates (μ) were calculated from the smolt tagging study in 1969-1973 at Sand Hill River (Reddin 1981; Reddin and Dempson 1989). Exploitation rates of 0.28-0.51 for small salmon and 0.83-0.97 for large salmon from the tagging study were changed to base exploitation rates of 0.3-0.5 on small salmon and 0.7-0.9 on large salmon and were assumed to apply to all of the salmon populations in SFAs 1, 2, and 14B for the period of 1969-1991 (Anon. 1993b). While fishing effort varied annually during that time it showed no substantial trends either decreasing or increasing until 1991. After 1991, due to the Management Plans for the

commercial fishery in Labrador and Newfoundland, several changes occurred that would potentially reduce exploitation on salmon in the commercial fishery. These changes include: (1) reductions in effort as commercial salmon fishermen chose to sell their licenses from a buyout agreement begun in 1992, (2) moratorium on commercial fishing in Newfoundland which would potentially increase the number of Labrador salmon in Labrador coastal waters, and (3) season reductions due to the varying opening dates and early closures from the quotas applied in 1995 and 1996. The effects of these changes were quantified in the exploitation model used to derive returns of Labrador salmon as follows:

Adjustment of Exploitation Rates due to Reductions in Fishing Effort -1

Licensed fishing effort in Labrador has declined considerably due to license buyouts as part of management measures designed to reduce commercial exploitation. Declines in fishing effort and its subsequent effect on exploitation rates were assessed by devaluing the base exploitation rates by the proportionate decrease in fishing effort as described in Anon. (1993). Anon. (1993) estimated the changes in exploitation from the following equation:

(2) $\mu = 1 - e^{-aF}$

where a = fraction of the 1991 licensed effort remaining in 1992-1996 and F = fishing effort in the base year. In 1994-1996, the licensed effort for all of Labrador was 37% of the 1991 level of 570 licenses, in 1993 it was 55%, and in 1992 it was 87% (see text table below). In any given year, it was assumed that 90% of licensed fishermen were active. Fishermen reported during public consultations that in 1995 and 1996 many licensed salmon fishermen did not fish for salmon in 1995-1996 but fished crab instead due to its much higher value. This was verified by Fisheries Officers who reported that of the 218 licensed salmon fishermen only 132 were active in 1996. Another method of obtaining actual effort information is also available since beginning in 1993 commercial fishing vessel numbers have been recorded on sales receipts issued to fishermen by fish plants. Enumeration of licensed salmon fishermen actively fished was made by determining the number of Commercial Fishing Vessels (CFV) in the Statistics Branch catch records. The numbers of licensed and active fishermen from the analysis of CFV are:

	1991	1992	1993	1994	1995	1996	1997
Licensed	570	495	288	218	218	218	205
Active	**513**	**446**	262	194	153	127	138

Active effort in 1991 and 1992 (in bold) was assumed to be 90% as it was in 1993 and 1994 from the CFV file. Thus, the exploitation rates (μ_e) were modified due to effort reductions in equation (2) using estimated active licenses from 1991 as a base and the number of active licenses in 1995, 1996 and 1997. The modified exploitation rates for 1992-1997 used the licensed effort in equation (2). The modified exploitation rates (μ_e) thus becomes:

		1969-1991	1992	1993	1994	1995	1996	1997
Small Salmon	Lower	0.30	0.27	0.16	0.12	0.10	0.08	0.09
	Upper	0.50	0.45	0.30	0.23	0.19	0.16	0.17
Large Salmon	Lower	0.70	0.65	0.46	0.36	0.30	0.26	0.28
	Upper	0.90	0.86	0.69	0.58	0.50	0.43	0.46

Adjustment for Newfoundland Fishery Closure - 2

The tagging study on Sand Hill River, 1969-1973, showed that Labrador small and large salmon were not only caught in Labrador but also in the commercial fisheries along the northeast coast of Newfoundland (both smalll and large) and at west Greenland (large only) (Anderson 1985). For small salmon, out of a total of 100 (1SW) tag returns there were 24 from Newfoundland. For large salmon, out of a total of 137 (2SW) tag returns there were 41 from Newfoundland. This occurs due to harsh environmental conditions along the coast of Labrador in the spring that push salmon further south on their return migration so that they migrate along the northeast coast of Newfoundland before turning northwards to Labrador and their home rivers.

For 1992-1997, the moratorium on commercial fishing in Newfoundland would have released small and large salmon to Labrador. The effect of salmon released from Newfoundland in 1992-1996 was evaluated against the exploitation rates in section A as follows:

(3) $\mu_n = (1-((24 * (1 - \mu_e))/100)) * \mu_e$, for small salmon and

$\mu_n = (1-((41 * (1 - \mu_e))/137)) * \mu_e$, for large salmon

These new estimates of fishing mortality (μ_n) in 1992-1994 included adjustments for the closure of the commercial fishery in Newfoundland based on the results of the Sand Hill River tagging study. They are as follows:

		1969-1991	1992	1993	1994	1995	1996	1997
Small Salmon	Lower	0.30	0.22	0.13	0.10	0.08	0.07	0.07
	Upper	0.50	0.39	0.25	0.19	0.15	0.12	0.14
Large Salmon	lower	0.70	0.58	0.38	0.29	0.24	0.20	0.22
	Upper	0.90	0.83	0.62	0.50	0.42	0.36	0.39

Adjustment for Season Reductions in Labrador - 3

In the Labrador commercial fishery, the Management Plans for 1995-1996 included alterations to the season opening and closing dates that effectively reduced the length of the fishing season and exploitation. In 1995, adjustments were made to account for the new opening date

of 3rd of July changed from 20th of June of the previous year. For 1995, the accumulative effect of these weighted to SFA catches was to reduce the catch such that for small salmon the current catch represented 86.0% of former small salmon catches and 62.7% of large salmon catches, calculated as the salmon caught in the current season compared to total catches in the former season. The base for these calculations was the catch in the years prior to 1995. In 1996, the opening date reverted to June 20 but the quota levels resulted in early closures in SFA 2 of 2A-July 10, 2B-July 8, and 2C-July 2 while SFA 1 and 14B did not close. For 1996, the accumulative effect of these weighted to SFA catches was to reduce the catch such that for small salmon the current catch represents 53% of small salmon and 61% of large salmon that were caught in a full fishing season. In 1997, the opening date remained at June 20 but the quota levels resulted in early closures in SFA 2 of 2A-July 12, 2B-July 15, and 2C-July 13 while SFA 1 closed on October 15 as the quota was not caught. For 1997, the accumulative effect of these early closures was to reduce the catch so that for small salmon the current catch represented 47% of small salmon and 64% of large salmon. The effect of season changes would be to reduce catches and hence lower exploitation rates. The effect of shorter seasons in 1995, 1996 and 1997 was evaluated against the exploitation rates in section B as follows:

(4) $\mu_{ss} = \mu_{ns} * SC$, for small salmon, where SC is proportionate season change effect on catch and

$\mu_{sl} = \mu_{nl} * SC$, for large salmon

The new estimates of fishing mortality including effort reductions, adjustments for the closure of the commercial fishery in Newfoundland, and shorter seasons due to opening dates and quotas results in the following exploitation rates which were applied to catches.

		1969-1991	1992	1993	1994	1995	1996	1997
Small Salmon	Lower	0.30	0.22	0.13	0.10	0.07	0.03	0.04
	Upper	0.50	0.39	0.25	0.19	0.13	0.06	0.08
Large Salmon	Lower	0.70	0.58	0.38	0.29	0.15	0.13	0.16
	Upper	0.90	0.83	0.62	0.50	0.26	0.23	0.28

The accumulative effect of factors 1, 2, and 3 was to reduce exploitation on Labrador origin salmon.

Labrador origin 2SW returns (LR_{2SW}) were derived from equation 1 by:

(5) $LR_{2SW} = LR * P_{2SW}$

where,

P_{2SW} = proportion of the large salmon that are 2SW salmon.

The SR_{1SW} values were calculated as in equation (5) but using P_{1SW} which is the proportion of the catch that is 1-sea winter in age and maturing to enter freshwater and spawning in the year of capture. The parameter values for P_{1SW} of 0.1 to 0.2 comes from Anon. (1991).

The 2SW component was estimated separately for salmon caught in SFA 1, 2 and 14B. In SFA 1, commercial sampling at Nain of large salmon showed the proportion of 2SW were on average about 84% (n=6,542), 1977-1991. Thus, a range of 0.7-0.9 was used for SFA 1. In SFA 2, commercial sampling of large salmon averaged 69% (n=4 793) 2SW salmon, 1977-1991. There were no commercial samples available for SFA 14B. Thus, for SFAs 2 and 14B, a range of 0.6-0.8 was used. For the 1SW component in SFA 1, commercial samples at Nain of small salmon showed the proportion of 1SW salmon were on average about 94% (n=4,757). In SFA 2, the 1SW component was on average about 97% (n=8,872) of small salmon. There were no samples from commercial sampling in SFA 14B. In 1997, aged commercial samples indicated that the previous range was acceptable.

Total river returns of 2SW salmon (TRR) were calculated as follows:

(6) $TRR = LR_{2SW} / (1- \mu_{si})$

The total river returns of small salmon are also calculated by equation 6 but from SR.

Spawning escapement (SE) was calculated according to the formula:

(7) $SE = TRR - AC$

where

AC = angling catch which includes retained catch plus 10% of hook and released salmon.

A couple of modifications were made to the estimation procedure for Labrador in 1997. Firstly, determination of exploitation rates were calculated separately for SFAs 1, 2 and 14B using the active effort individually for each SFA. For SFA 1, the active number of licenses declined from 141 in 1991 to 39 in 1997. For SFA 2, the active number of licenses declined from 320 in 1991 to 99 in 1997. For SFA 14B, active licenses declined from 52 in 1991 to 0 in 1997 when the fishery was closed. Exploitation rates determined as in equations 2, 3 and 4 are: SFA 1 – small was 0.0735 to 0.1399 and large was 0.2221 to 0.3959; and SFA 2 – small was 0.0384 to 0.0728 and - large was 0.1589 to 0.2799. The SAS code for the simulation model is as follows:

For large salmon:

```
DATA D2;  SET CATCH;
SEED = 0;
DO SIM = 1 TO 2500;
  R_EXP1 = (EXP_L1 + (EXP_H1 - EXP_L1) * RANUNI(SEED));
  R_EXP2 = (EXP_L2 + (EXP_H2 - EXP_L2) * RANUNI(SEED));
  R_LAB1 = (LAB1_L + (LAB1_H - LAB1_L) * RANUNI(SEED));
  R_LAB2 = (LAB2_L + (LAB2_H - LAB2_L) * RANUNI(SEED));
  R_SF12 = (SF12_L + (SF12_H - SF12_L) * RANUNI(SEED));
  R_SF22 = (SF22_L + (SF22_H - SF22_L) * RANUNI(SEED));
  R_PSF14 = (SF14_L + (SF14_H - SF14_L) * RANUNI(SEED));
  R_ANG2 = (ANG_SF1*R_SF12)+(ANG_SF2*R_SF22)+(ANG_SF14*R_SF22);
  ANG_CATL = (ANG_SF1+ANG_SF2+ANG_SF14);
LAB_POP2=(((SFA1*R_LAB1)/R_EXP1)*R_SF12)+(((SFA2*r_LAB2)/R_EXP2)*R_SF22)+R_P
SF14;
```

```
 LAB_RIV2=LAB_POP2-((SFA1*R_LAB1*R_SF12)+(SFA2*R_LAB2*R_SF22));
 LAB_SP2=LAB_RIV2-R_ANG2;
 LAB_POPL=((SFA1*R_LAB1)/R_EXP1)+((SFA2*R_LAB2)/R_EXP2)+R_PSF14;
 LAB_RIVL=LAB_POPL-((SFA1*R_LAB1)+(SFA2*R_LAB2));
 LAB_SPL=LAB_RIVL-ANG_CATL;
OUTPUT;
END;
```

For small salmon:

```
DATA D1;  SET CATCH;
SEED = 0;
DO SIM = 1 TO 2500;
 RAN_EXP1 = (EXP_L1 + (EXP_H1 - EXP_L1) * RANUNI(SEED));
 RAN_EXP2 = (EXP_L2 + (EXP_H2 - EXP_L2) * RANUNI(SEED));
 RAN_LAB1 = (LAB1_L + (LAB1_H - LAB1_L) * RANUNI(SEED));
 RAN_LAB2 = (LAB2_L + (LAB2_H - LAB2_L) * RANUNI(SEED));
 RAN_NMAT= (NMAT_L + (NMAT_H - NMAT_L) * RANUNI(SEED));
 RAN_SF14= (SF14_L + (SF14_H - SF14_L) * RANUNI(SEED));
LAB_POP1=(((SFA1*RAN_LAB1)/RAN_EXP1)*RAN_NMAT)+(((SFA2*RAN_LAB2)/RAN_EXP2
)*RAN_NMAT)+RAN_SF14;
 LAB_RIV1=LAB_POP1-((SFA1*RAN_LAB1*RAN_NMAT)+(SFA2*RAN_LAB2*RAN_NMAT));
 LAB_SP1=LAB_RIV1-ANG_CAT1;
OUTPUT;
END;
```

Numbers of small and large salmon for SFAs 1 and 2 were estimated from the exploitation model while for SFA 14B the results of assessments on Forteau Brook and Pinware River were expanded to include all of the rivers in SFA 14B. This was necessary because the commercial fishery was closed in SFA 14B in 1997 and there were no commercial catches to use to derive returns. Returns to SFA 14B were 663-1545 small salmon and 146-327 large salmon.

Total Mortalities of Labrador Origin Salmon (Labrador PFA)

Total mortalities of small and large salmon were accounted for by summing commercial catches of small salmon in Labrador and Newfoundland, large salmon in Labrador, Newfoundland, and Greenland, angling catches in Labrador of small and large salmon including 10% of the hook and released salmon, and small and large spawners. All of the above mortality estimates except catches of Labrador salmon in Newfoundland, 1969-1991 and Greenland could be obtained from equations 1 to 7. Catches in Newfoundland and Greenland were assessed by:

Greenland: for 1969-1992 and 1995-2008, removals of Labrador salmon by the Greenland fishery were assessed from data based on the sampling program in commercial fish plants at west Greenland (Anon. 1996). The Greenland fishery catches salmon that would have returned to homewaters as large salmon in the year following the Greenland fishery. Numbers of Labrador salmon were determined by converting catches in kg to numbers of salmon of 1SW North American origin that were of river age 4 and older. The number of Labrador salmon were estimated by assuming that 70% of the production of 4-year and older river age salmon are from Labrador (Anon. 1993b).

Newfoundland: for 1969-1991, catches of Labrador small and large salmon in Newfoundland were included in total mortalities as the product of the ratio of tags caught in Newfoundland to Labrador and the catch in Labrador. For small salmon the ratio was (24/(100-24)) = 0.32 and for large salmon it was (41/(137-41) = 0.43.

Returns and Spawners for Labrador, 1998-2001

In Labrador, for the years 1998-2001, there was no data available with which to estimate returns and spawners because the commercial fishery had closed and there were only one or two in-river counting fence projects. Consequently, previous analyses for Labrador used raising factors estimated based on the proportion that Labrador 1SW and 2SW salmon were to the total PFA during the years when Labrador estimates were available (Reddin 1999). These factors (1.04-1.49 for 1SW salmon and 1.05-1.27 for 2SW salmon) were multiplied by the PFA in 1998-2001 to provide values for returns and spawners to Labrador. At the 2009 ICES Working Group North Atlantic Salmon (WGNAS) meeting, it was decided to re-examine the Labrador data to find a new method of determining returns and spawners for the 1998-2001 period that utilized data from Labrador rather than the PFA which includes data from outside Labrador as was described above (Anon. 2009). In order to provide new estimates of returns and spawners for Labrador for 1998-2001, two data series were examined one being angling catch data and the other the food fishery landings (Tables 3a and 3b). The various food fisheries and derivation of their landings are described in Reddin et al. (2005). Since there were no FSC landings in 1998 and because of a perceived effect on landings of increasing effort in FSC fisheries in 1999-2001 compared to 2002 to present it was decided to use the angling data. The return estimates of small, large, and 2SW salmon for 2002-2008 were used to determine exploitation rates based on small retained fish and large retained and hooked-and-released in the angling fishery. The average of these exploitation rates for the years 2002-2008 were then applied to the angling catches in 1998-2001 to provide new estimates of returns in those years. The spawners for Labrador were derived by subtracting the angling catches from the returns.

Returns and Spawners for Labrador, 2002 to Present

The basis for estimates of 2SW and 1SW salmon returns and spawners for Labrador (SFAs 1, 2 and 14B) prior to 1998 are catch data from angling and commercial fisheries. In 1998, the commercial fishery in Labrador was closed which has continued to the present, and so the model developed to determine returns and spawners from commercial catch data cannot be used. For 2002 to the present, there were stock assessment projects that took place on four Labrador rivers where migrating salmon were counted, out of about 100 extant salmon rivers. Because they were on the same four rivers each year, it was possible to extrapolate from return rates for small and large salmon per accessible drainage areas in these four rivers to rivers without counting facilities in the remainder of Labrador rivers. The accessible drainages for the various areas in Labrador are 25,485 km^2 for Northern Labrador (SFA 1A), 9,267 km^2 for Lake Melville (SFA 1B), 28,160 km^2 for Southern Labrador (SFA 2), and 2,651 km^2 for the Straits Area (SFA 14B). Accessible drainage area in the counting facility rivers was 1,878 km^2 resulting in an expansion factor of 35 to one. Not all rivers in Lake Melville were included due to a lack of information on presence of salmon populations in rivers in this region of Labrador. Lake Melville rivers whose drainage areas were included are Sebaskachu, Cape Caribou, Goose, MacKenzie (Churchill), Kenamu, Caroline, and Traverspine.

This is a crude method for deriving returns and spawners for Labrador and if additional information on drainage areas and/or information from counting fences becomes available particularly for Lake Melville these should be added in the future and then used in the derivation of returns and spawners. The text table below shows the return rates of small and large salmon per km^2 developed for the counting fence rivers (Table 3c) for the four areas of Labrador used to derive returns and spawners for the period of 2002 to present:

Area	Size	2002	2003	2004	2005	2006	2007	2008
Northern Labrador (SFA 1A)	Small	0.47-2.57	0.28-1.84	0.28-0.62	1.45-3.94	1.27-6.47	1.75-6.21	1.61-5.24
	Large	0.05-0.45	0.021-0.28	0.08-0.32	0.05-0.40	0.10-0.61	0.07-0.61	0.10-0.72
Lake Melville (SFA 1B)	Small	0.47-2.57	0.28-1.84	0.28-0.62	1.45-3.94	1.27-6.47	1.75-6.21	1.29-4.19
	Large	0.05-0.45	0.021-0.28	0.08-0.32	0.05-0.40	0.10-0.61	0.07-0.61	0.09-0.69
Southern Labrador (SFA 2)	Small	0.50-2.72	0.41-2.75	1.60-3.56	2.23-6.07	0.85-4.30	0.79-2.79	1.29-4.19
	Large	0.05-0.49	0.04-0.54	0.13-0.52	0.09-0.76	0.08-0.49	0.07-0.60	0.09-0.69
Straits (SFA 14B)	Small	0.50-2.72	0.41-2.75	1.60-3.56	2.23-6.07	0.85-4.30	0.79-2.79	1.29-4.19
	Large	0.05-0.49	0.04-0.54	0.13-0.52	0.09-0.76	0.08-0.49	0.07-0.60	0.09-0.69

Return rates for SFAs 1A and 1B were derived from English River return rates with maximum and minimum values developed using the observed variability of return rates in SFA 2.

Total returns and spawners for Labrador, 2002 to present were estimated by Monte Carlo simulation based on 10,000 random draws from the range of values in the above table assuming return rates per km^2 of accessible drainage were uniformly distributed. The return rates for each SFA were then multiplied times the total accessible drainage area to derive total returns of small and large salmon. Because the returns are estimated from in-river data, the ranges of values were developed to convert numbers of small and large salmon to numbers of 1SW and 2SW salmon from scale age information collected from counting fences and angling fisheries in Labrador. In total, for the years 2002-2003, there were 1,392 small salmon and 244 large salmon samples available. A bootstrap procedure was used to develop estimates of the proportions of sea age 1 salmon in estimates of small salmon returns and spawners, proportions of sea age 2 salmon in estimates of large salmon returns and spawners and proportions of sea age 1 salmon in the estimates of large salmon returns. In order to do this, datasets of 200 each were randomly created from the available samples and then interpreted to provide the sea age distribution for both small and large salmon. This was repeated 10,000 and the 95^{th} C.I. from the distribution of outputs used to adjust the numbers of small and large salmon.

Sea age correction factors were:

Small to 1SW - 96 to 100%
Large to 2SW – 60 to 71%
Small overlap in large – 12 to 21%

Spawners of 1SW and 2SW salmon were derived similar to previous years by subtraction of angling catches including an estimate of hook and release mortalities from the returns.

RESULTS AND DISCUSSION

RETURNS AND SPAWNERS FOR LABRADOR

The following description of returns and spawners uses the mid-points of the minimum and maximum values in the tables. The mid-point of returns of 1SW salmon to rivers in Labrador in 2008 were estimated at 201,069 while spawners were 198,196 (Table 4 and Fig. 1) which is above the conservation requirement of 50,500 salmon. The spawning escapement of 1SW salmon remains high due to the low level of removals in the various fisheries relative to the stock size. The mid-point of the estimated numbers of 2SW returns is 17,785 in 2008 which is an increase from the previous year but remains very low compared to earlier years in the time series (Table 5 and Fig. 2). Spawning escapement of 2SW salmon remains below the conservation requirements of 34,746. Conservation requirements for small, large and 2SW salmon Labrador rivers were developed by O'Connell et al. (1997). This assumes that the catches are an absolute measure of fishing mortality on Labrador stocks which may not be correct due to freshwater and marine poaching.

Issues

In 2002-2008, estimates of returns and spawners derived from four counting facilities to those with none could lead to significant over and under-estimates of returns. This is especially a problem for SFAs 1B and 14B where stock sizes are unknown due to a lack of data and may be quite different from those in the other SFAs where counting facilities are present. Also, in the period, 1969-1997, exploitation rates in the commercial fishery are only available from one river, viz. Sand Hill River, and may be different if exploitation rates were available for other rivers. Defining the stock status of salmon in Labrador rivers has always been a challenge due to the remoteness and cost of working there. In spite of those difficulties if managers wish to have science advice appropriate to the entire area then ways and means will have to be found to increase the number of facilities beyond the four currently present.

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Table 3a. New estimates of small returns and spawners for Labrador. Years shown in yellow are the years for which returns are to be estimated.

	Prior to correction for 1998-2001													New estimates of 1998-2001			
	Small Returns		Small angled retained			Exploitation			FSC Small			Exploitation		Angling catches		FSC landings	
Year	Min	Max	SFA 1	SFA 2	SFA 14B	Total	Min	Max	SFA1	SFA 2	Total	Min	Max	Min	Max	Min	Max
1969	32526	51629	234	1612	1265	3111	0.06	0.10									
1970	44278	70283	275	2172	1566	4013	0.06	0.09									
1971	57691	91573	171	2836	927	3934	0.04	0.07									
1972	43181	68541	450	2074	423	2947	0.04	0.07									
1973	9448	14997	533	5528	1431	7492	0.50	0.79									
1974	47310	75095	347	1414	740	2501	0.03	0.05									
1975	93904	149055	379	2524	1069	3972	0.03	0.04									
1976	65696	104279	891	2337	2498	5726	0.05	0.09									
1977	58466	92803	688	2244	1662	4594	0.05	0.08									
1978	28271	44875	875	1243	573	2691	0.06	0.10									
1979	38400	60952	905	2312	901	4118	0.07	0.11									
1980	86922	137972	704	2158	938	3800	0.03	0.04									
1981	96331	152907	669	2824	1698	5191	0.03	0.05									
1982	66737	105932	834	1999	1271	4104	0.04	0.06									
1983	41530	65921	488	1884	2000	4372	0.07	0.11									
1984	21496	34120	702	1246	987	2935	0.09	0.14									
1985	39782	63145	642	1367	1092	3101	0.05	0.08									
1986	59973	95195	421	1972	1071	3464	0.04	0.06									
1987	75141	119272	854	2625	1887	5366	0.04	0.07									
1988	69812	110812	1278	2653	1592	5523	0.05	0.08									
1989	47448	75315	1269	2242	1173	4684	0.06	0.10									
1990	27743	44036	563	1680	1066	3309	0.08	0.12									
1991	22485	35691	130	1041	1152	2323	0.07	0.10									
1992	28911	53672	283	1599	856	2738	0.05	0.09									
1993	36225	78158	121	1340	1047	2508	0.03	0.07									
1994	25134	57084	453	1437	659	2549	0.04	0.10									
1995	33544	79207	500	1232	761	2493	0.03	0.07									
1996	67074	164914	260	1405	900	2565	0.02	0.04									
1997	86965	180782	300	1335	730	2365	0.01	0.03									
1998	9519	202759	256	1011	864	2131	0.01	0.22						97408	205197		
1999	6970	197940	350	1329	397	2076	0.01	0.30	2739	0	2739	0.01	0.39	94894	199901	30440	62184
2000	4146	227404	363	1480	718	2561	0.01	0.62	4111	1212	5323	0.02	1.28	117083	246602	59157	120849
2001	3525	178026	352	1151	546	2049	0.01	0.58	3394	1396	4790	0.03	1.36	93660	197301	53233	108748
2002	62321	142951	129	1328	614	2071	0.01	0.03	3609	2197	5806	0.04	0.09				
2003	48256	122813	174	1274	664	2112	0.02	0.04	4382	2095	6477	0.05	0.13				
2004	69808	120244	116	1228	464	1808	0.02	0.03	4822	3564	8386	0.07	0.12				
2005	160038	281401	192	1377	438	2007	0.01	0.01	4958	5479	10437	0.04	0.07				
2006	132205	294669	170	977	509	1656	0.01	0.01	5422	4955	10377	0.04	0.08				
2007	131895	257360	185	1088	489	1762	0.01	0.01	4700	4507	9207	0.04	0.07				
2008	142851	264694	153	1075	460	1688	0.01	0.01	5154	4680	9834	0.04	0.07				

Table 3b. New estimates of large returns and spawners for Labrador. Years shown in yellow are the years for which returns are to be estimated.

	Prior to correction for 1998-2001													New estimates of 1998-2001			
	Large Returns		Large angled retained&releas				Exploitation		FSC Large			Exploitation		Angling catches		FSC landings	
Year	Min	Max	SFA 1	SFA 2	FA 14B	Total	Min	Max	SFA1	SFA 2	Total	Min	Max	Min	Max	Min	Max
1969	5203	25318	176	120	273	569	0.02	0.11									
1970	4847	24928	129	112	321	562	0.02	0.12									
1971	6907	35522	82	157	247	486	0.01	0.07									
1972	5937	30535	170	174	80	424	0.01	0.07									
1973	8303	42700	128	449	432	1009	0.02	0.12									
1974	8184	42091	311	201	291	803	0.02	0.10									
1975	7635	39264	117	56	154	327	0.01	0.04									
1976	8769	45099	368	152	310	830	0.02	0.09									
1977	7799	40107	533	160	593	1286	0.03	0.16									
1978	6098	31362	432	152	183	767	0.02	0.13									
1979	3483	17910	430	60	119	609	0.03	0.17									
1980	8330	42842	232	320	337	889	0.02	0.11									
1981	7489	38515	195	105	220	520	0.01	0.07									
1982	5550	28540	379	162	80	621	0.02	0.11									
1983	4014	20644	137	161	130	428	0.02	0.11									
1984	2880	14812	222	103	185	510	0.03	0.18									
1985	2266	11655	135	59	100	294	0.03	0.13									
1986	3904	20079	129	154	184	467	0.02	0.12									
1987	5278	27144	141	277	215	633	0.02	0.12									
1988	3307	17005	171	288	251	710	0.04	0.21									
1989	3183	16369	144	264	53	461	0.03	0.14									
1990	1832	9424	115	144	98	357	0.04	0.19									
1991	898	4617	8	36	49	93	0.02	0.10									
1992	3986	18714	335	218	238	791	0.04	0.20									
1993	6199	22173	47	150	272	469	0.02	0.08									
1994	9080	29659	210	464	128	802	0.03	0.09									
1995	19973	53959	189	490	237	916	0.02	0.05									
1996	14725	40004	67	534	222	823	0.02	0.06									
1997	14637	32901	71	235	418	724	0.02	0.05									
1998	21886	50512	170	524	351	1045	0.02	0.05						7374	19486		
1999	5245	30259	206	707	338	1251	0.04	0.24	1084	0	1084	0.04	0.21	8827	23328	4189	10833
2000	7106	32391	311	644	753	1708	0.05	0.24	1092	260	1352	0.04	0.19	12052	31850	5224	13512
2001	7869	36361	205	1154	447	1806	0.05	0.23	1299	374	1673	0.05	0.21	12744	33677	6464	16720
2002	9076	24769	168	556	461	1185	0.05	0.13	1015	422	1437	0.06	0.16				
2003	6676	21689	669	584	295	1548	0.07	0.23	1639	536	2175	0.10	0.33				
2004	10964	23092	606	933	239	1778	0.08	0.16	2210	1486	3696	0.16	0.34				
2005	11159	30796	228	829	524	1581	0.05	0.14	1687	1130	2817	0.09	0.25				
2006	12414	29783	385	594	381	1360	0.05	0.11	1639	1451	3090	0.10	0.25				
2007	11887	31913	276	584	597	1457	0.05	0.12	1560	1092	2652	0.08	0.22				
2008	14700	37677	472	562	342	1376	0.04	0.09	2955	954	3909	0.10	0.27				

Table 3c. Returns per km^2 drainage area to four rivers in Labrador, 2002-2008.

River	SFA	Size	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
English	1A	Small			0.47	2.94	1.79	1.52	1.06	0.45	2.70	3.87	3.98	3.42
		Large			0.38	0.12	0.33	0.25	0.15	0.20	0.22	0.35	0.34	0.41
Big Brook	1A	Small	0.67	1.00		1.24								
		Large	0.13	0.24		0.19								
S'west Br	2	Small		0.29	0.86		0.84	0.61	0.41	1.60	2.23	0.85	0.79	1.29
		Large		0.01	0.11		0.08	0.09	0.04	0.14	0.14	0.09	0.08	0.09
Muddy Bay	2	Small						0.50	1.85	2.13	2.44	2.09	1.13	2.23
		Large						0.05	0.15	0.13	0.09	0.08	0.07	0.17
Sand Hill River	2	Small						2.72	2.75	3.47	6.07	4.30	2.79	4.19
		Large						0.49	0.54	0.52	0.76	0.49	0.60	0.69

Table 4. Estimates of 1SW spawners, returns and recruits for Labrador.

Year	Commercial Small Catch	Food Fisheries Small Catch	Grilse Recruits SFA 1, 2 & 14B +Nfld		Grilse to rivers SFA 1,2&14B		Labrador grilse spawners Angling catch subtracted SFA 1, 2 & 14B	
			Min	Max	Min	Max	Min	Max
1969	38722	0	48912	122280	18587	65053	15476	61942
1970	29461	0	66584	166459	25302	88556	21289	84543
1971	38359	0	86754	216884	32966	115382	29032	111448
1972	28711	0	64934	162335	24675	86362	21728	83415
1973	6282	0	14208	35520	5399	18897	0	11405
1974	37145	0	71142	177856	27034	94619	24533	92118
1975	57560	0	141210	353024	53660	187809	49688	183837
1976	47468	0	98790	246976	37540	131391	31814	125665
1977	40539	0	87918	219796	33409	116931	28815	112337
1978	12535	0	42513	106282	16155	56542	13464	53851
1979	28808	0	57744	144360	21943	76800	17825	72682
1980	72485	0	130710	326776	49670	173845	45870	170045
1981	86426	0	144859	362147	55046	192662	49855	187471
1982	53592	0	100357	250892	38136	133474	34032	129370
1983	30185	0	62452	156129	23732	83061	19360	78689
1984	11695	0	32324	80811	12283	42991	9348	40056
1985	24499	0	59822	149555	22732	79563	19631	76462
1986	45321	0	90184	225461	34270	119945	30806	116481
1987	64351	0	112995	282486	42938	150283	37572	144917
1988	56381	0	104980	262449	39892	139623	34369	134100
1989	34200	0	71351	178377	27113	94896	22429	90212
1990	20699	0	41718	104296	15853	55485	12544	52176
1991	20055	0	33812	84531	12849	44970	10526	42647
1992	13336	0	29632	79554	17993	62094	15229	59331
1993	12037	0	33382	93231	25186	80938	22499	78251
1994	4535	0	22306	63109	18159	56888	15242	53971
1995	4561	0	28852	82199	25022	76453	22199	73630
1996	5308	0	55634	159204	51867	153553	48924	150610
1997	8025	0	72467	176071	66972	169030	64389	166446
1998	0	2988	101404	212664	98293	209289	95786	206782
1999	0	2739	98685	207684	95953	204800	93436	202283
2000	0	5323	123728	258738	118509	253290	115239	250020
2001	0	4790	99940	209371	95189	204373	92676	201860
2002	0	5806	65982	149798	60294	143864	57718	141288
2003	0	6477	53058	130423	46644	123683	44040	121079
2004	0	8386	76044	130397	67633	121486	65228	119081
2005	0	10437	163628	290142	153375	279426	150656	276707
2006	0	10377	137313	302798	127084	292083	124847	289846
2007	0	9207	135792	265829	126727	256341	124501	254115
2008	0	9834	147284	275025	137472	264665	135319	262512

Estimates are based on

EST SMALL RETURNS - (COMM CATCH*PROP LAB ORIGIN) EXP RATE.

PROP SFAs1,2&14B - 6- 8, SFA 1-0.36-0.42&SFA 2-0.75-0.85(97)

EXP RATE-SFAs1,2&14B - 3- 5(69-91), 22- 39(92), 13- 25(93),

- 10- 19(94), 07- 13(95), 04- 07(96), SFA 1-0.07-0.14&SFA 2-0.04-0.07 (97)

EST GRILSE RETURNS CORRECTED FOR NON-MATURING 1SW - (SMALL RET*PROP GRILSE).

PROP GRILSE SFAs1,2&14B - 0.8-0.9

EST RET TO FRESHWATER - (EST GRILSE RET-GRILSE CATCHES)

EST GRILSE SPAWNERS - EST GRILSE RETURNS TO FRESHWATER - GRILSE ANGLING CATCHES

Returns in 1998-2001 were estimated from angling exploitation rates

Returns in 2002 to present are from counting fence returns and drainage areas

Table 5. Estimates of 2SW spawners, returns and recruits for Labrador.

Year	Commercial Large Catch	Food Fisheries Small Catch	Labrador 2SW Recruits SFAs 1,2 &14B		Labrador at Greenland	Totals		Labrador 2SW to rivers in SFAs 1,2 &14B		Labrador 2SW spawners in SFAs 1,2 &14B Angling catch subtracted	
			Min	Max		Min	Max	Min	Max	Min	Max
1969	78052	0	32483	69198	34280	80636	133032	3248	20760	2890	20287
1970	45479	0	30258	68490	56379	99561	154121	3026	20547	2676	20085
1971	64806	0	43117	97596	24209	85831	163577	4312	29279	4012	28882
1972	55708	0	37064	83895	59203	112096	178927	3706	25168	3435	24812
1973	77902	0	51830	117319	22348	96314	189771	5183	35196	4565	34376
1974	93036	0	50030	113827	38035	109433	200476	5003	34148	4490	33475
1975	71168	0	47715	107974	40919	109012	195006	4772	32392	4564	32119
1976	77796	0	55186	124671	67730	146485	245646	5519	37401	4984	36701
1977	70158	0	48669	110171	28482	97937	185706	4867	33051	4042	31969
1978	48934	0	38644	87155	32668	87816	157045	3864	26147	3361	25490
1979	27073	0	22315	50194	18636	50481	90267	2231	15058	1823	14525
1980	87067	0	51899	117530	21426	95490	189152	5190	35259	4633	34525
1981	68581	0	47343	106836	32768	100331	185233	4734	32051	4403	31615
1982	53085	0	34910	78873	43678	93497	156236	3491	23662	3081	23127
1983	33320	0	25378	57268	30804	67021	112531	2538	17181	2267	16824
1984	25255	0	18063	40839	4026	29802	62306	1806	12252	1478	11822
1985	16789	0	14481	32596	3977	24644	50494	1448	9779	1258	9530
1986	34071	0	24703	55734	17738	52991	97275	2470	16720	2177	16334
1987	49799	0	32885	74471	29695	76625	135970	3289	22341	2895	21821
1988	32386	0	20681	46789	27842	57355	94614	2068	14037	1625	13452
1989	26836	0	20181	45509	26728	55528	91673	2018	13653	1727	13270
1990	17316	0	11482	25967	9771	26158	40828	1148	7790	923	7493
1991	7679	0	5477	12467	7779	15596	25571	548	3740	491	3665
1992	19608	0	14756	37045	13713	28469	50758	2515	15548	2012	14889
1993	9651	0	10242	29482	6592	16834	36074	3858	18234	3624	17922
1994	11056	0	11396	34514	0	11396	34514	5653	24396	5347	23992
1995	8714	0	16520	51530	0	16520	51530	12368	44205	12083	43828
1996	5479	0	11814	37523	4960	16773	42483	9113	32759	8878	32448
1997	5550	0	12605	31973	5161	17766	37134	8919	26674	8785	26497
1998	0	2269	5786	15446	3990	9776	19436	4424	13835	4237	13614
1999	0	1084	5947	17332	506	6453	17838	5296	16563	5049	16269
2000	0	1352	8043	23573	873	8915	24446	7231	22613	6987	22325
2001	0	1673	8650	25099	1232	9882	26331	7646	23911	7355	23567
2002	0	1437	6308	18606	2958	9265	21564	5446	17586	5263	17370
2003	0	2175	5311	16943	387	5698	17331	4086	15399	3793	15147
2004	0	3696	8796	19019	554	9350	19573	6578	16395	6332	16104
2005	0	2817	8386	23865	727	9112	24592	6695	21865	6443	21567
2006	0	3090	9302	23340	1016	10318	24356	7448	21146	7244	20904
2007	0	2652	8723	24541	1362	10086	25903	7132	22658	6918	22405
2008	0	3909	11165	29526	1669	12834	31195	8820	26751	8613	26505

Estimates are based on

EST LARGE RETURNS = (COMM CATCH*PROP LAB ORIGIN)/EXP RATE. PROP SFAs1,2&14B = 6-8 SFA 1: 0.64-0.72 & SFA 2 0.88-0.95 (97)

EXP RATE SFAs1,2&14B = 7-9(69-91); 58-83(92); 38-62(93); 29-50(94); 15-26(95); 11-23(96); . SFA 1: 0.22-0.40; SFA 2: 0.16-0.28 (97)

EST 2SW RETURNS = (EST LARGE RETURNS*PROP 2SW). PROP 2SW SFA 1 = 7-9 SFAs 2&14B = 6-8

WG = are North American 1SW salmon of river age 4 and older of which 70% are Labrador origin

EST RET TO FRESHWATER = (EST 2SW RET-2SW CATCHES)

EST 2SW SPAWNERS = EST 2SW RETURNS TO FRESHWATER - 2SW ANGLING CATCHES

Returns in 1998-2001 were estimated from angling exploitation rates

Returns in 2002 to present are from counting fence returns and drainage areas

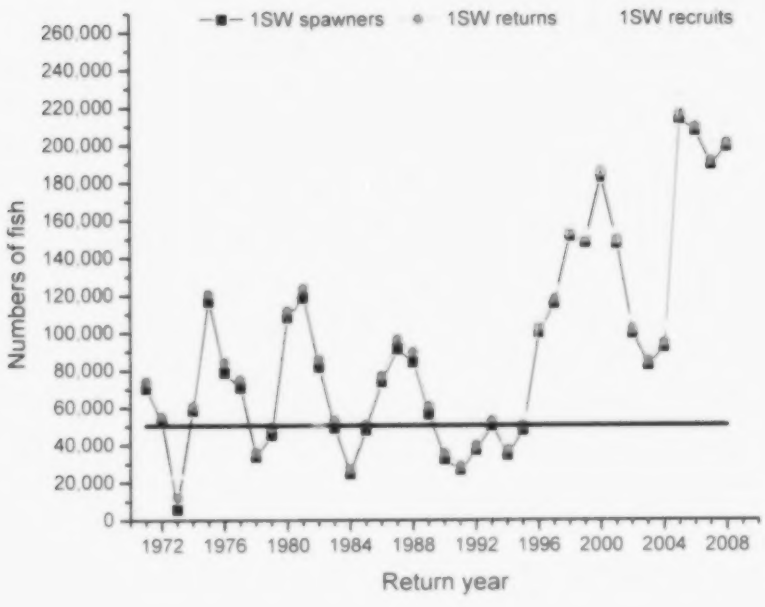

Figure 1. The number of 1SW recruits, returns and spawners for Labrador, 1969-2008.

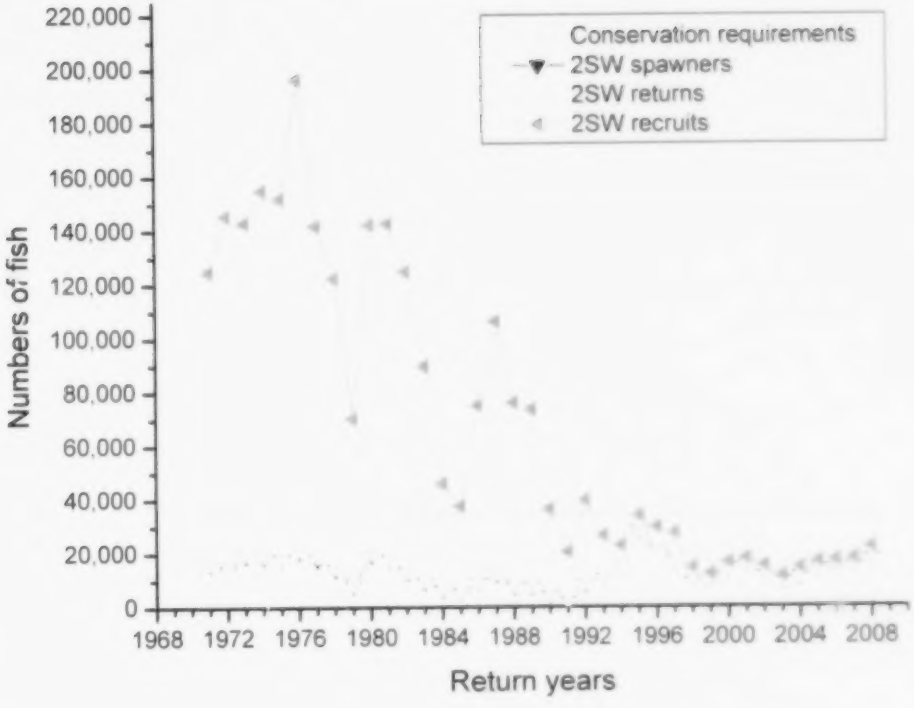

Figure 2. The number of recruits, returns and spawners for Labrador, 1969-2008.

Table 1. Parameter values for run reconstruction model for 1SW salmon.

	Parameter value for Labrador origin						Exploitation rates						Proportion in small catch of non-maturing 1SW salmon					
Year	SFA 1		SFA 2		SFA 14B		SFA 1		SFA 2		SFA 14B		SFA 1		SFA 2		SFA 14B	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1969	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1970	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1971	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1972	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1973	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1974	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1975	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1976	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1977	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1978	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1979	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1980	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1981	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1982	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1983	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1984	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1985	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1986	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1987	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1988	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1989	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1990	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1991	0.6	0.8	0.6	0.8	0.6	0.8	0.3	0.5	0.3	0.5	0.3	0.5	0.80	0.90	0.80	0.90	0.80	0.90
1992	0.6	0.8	0.6	0.8	0.6	0.8	0.22	0.39	0.22	0.39	0.22	0.39	0.80	0.90	0.80	0.90	0.80	0.90
1993	0.6	0.8	0.6	0.8	0.6	0.8	0.13	0.25	0.13	0.25	0.13	0.25	0.80	0.90	0.80	0.90	0.80	0.90
1994	0.6	0.8	0.6	0.8	0.6	0.8	0.10	0.19	0.10	0.19	0.10	0.19	0.80	0.90	0.80	0.90	0.80	0.90
1995	0.6	0.8	0.6	0.8	0.6	0.8	0.07	0.13	0.07	0.13	0.07	0.13	0.80	0.90	0.80	0.90	0.80	0.90
1996	0.6	0.8	0.6	0.8	0.6	0.8	0.04	0.07	0.04	0.07	0.04	0.07	0.80	0.90	0.80	0.90	0.80	0.90
1997	0.3557	0.4163	0.7480	0.8500	0.6000	0.8000	0.07	0.14	0.04	0.07	0.04	0.07	0.80	0.90	0.80	0.90	0.80	0.90
1998	1.0	1.0	1.0	1.0	1.0	1.0	0.07	0.14	0.04	0.07	0.04	0.07	0.95	0.97	0.95	0.97	0.95	0.97
1999	1.0	1.0	1.0	1.0	1.0	1.0	0.07	0.14	0.04	0.07	0.04	0.07	0.95	0.97	0.95	0.97	0.95	0.97
2000	1.0	1.0	1.0	1.0	1.0	1.0	0.07	0.14	0.04	0.07	0.04	0.07	0.95	0.97	0.95	0.97	0.95	0.97
2001	1.0	1.0	1.0	1.0	1.0	1.0	0.07	0.14	0.04	0.07	0.04	0.07	0.95	0.97	0.95	0.97	0.95	0.97
2002	1.0	1.0	1.0	1.0	1.0	1.0	0.07	0.14	0.04	0.07	0.04	0.07	0.95	0.97	0.95	0.97	0.95	0.97
2003	1.0	1.0	1.0	1.0	1.0	1.0	0.07	0.14	0.04	0.07	0.04	0.07	0.95	0.97	0.95	0.97	0.95	0.97
2004	1.0	1.0	1.0	1.0	1.0	1.0	0.07	0.14	0.04	0.07	0.04	0.07	0.95	0.97	0.95	0.97	0.95	0.97
2005	1.0	1.0	1.0	1.0	1.0	1.0	0.07	0.14	0.04	0.07	0.04	0.07	0.95	0.97	0.95	0.97	0.95	0.97
2006	1.0	1.0	1.0	1.0	1.0	1.0	0.07	0.14	0.04	0.07	0.04	0.07	0.95	0.97	0.95	0.97	0.95	0.97
2007	1.0	1.0	1.0	1.0	1.0	1.0	0.07	0.14	0.04	0.07	0.04	0.07	0.95	0.97	0.95	0.97	0.95	0.97
2008	1.0	1.0	1.0	1.0	1.0	1.0	0.07	0.14	0.04	0.07	0.04	0.07	0.95	0.97	0.95	0.97	0.95	0.97

Table 2. Parameter values for run reconstruction model for 2SW salmon.

	Parameter value for Labrador origin						Exploitation rates						Proportion in catch of 2SW salmon					
Year	SFA 1		SFA 2		SFA 14B		SFA 1		SFA 2		SFA 14B		SFA 1		SFA 2		SFA 14B	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1969	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1970	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1971	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1972	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1973	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1974	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1975	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1976	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1977	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1978	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1979	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1980	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1981	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1982	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1983	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1984	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1985	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1986	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1987	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1988	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1989	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1990	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1991	0.6	0.8	0.6	0.8	0.6	0.8	0.7	0.9	0.7	0.9	0.7	0.9	0.70	0.90	0.60	0.80	0.60	0.80
1992	0.6	0.8	0.6	0.8	0.6	0.8	0.58	0.83	0.58	0.83	0.58	0.83	0.70	0.90	0.60	0.80	0.60	0.80
1993	0.6	0.8	0.6	0.8	0.6	0.8	0.38	0.62	0.38	0.62	0.38	0.62	0.70	0.90	0.60	0.80	0.60	0.80
1994	0.6	0.8	0.6	0.8	0.6	0.8	0.29	0.50	0.29	0.50	0.29	0.50	0.70	0.90	0.60	0.80	0.60	0.80
1995	0.6	0.8	0.6	0.8	0.6	0.8	0.14	0.25	0.14	0.25	0.14	0.25	0.70	0.90	0.60	0.80	0.60	0.80
1996	0.6	0.8	0.6	0.8	0.6	0.8	0.13	0.23	0.13	0.23	0.13	0.23	0.70	0.90	0.60	0.80	0.60	0.80
1997	0.6433	0.7247	0.8839	0.9521	0.6000	0.8000	0.22	0.40	0.16	0.28	0.13	0.23	0.70	0.90	0.60	0.80	0.60	0.80
1998	1.0	1.0	1.0	1.0	1.0	1.0	0.22	0.40	0.16	0.28	0.13	0.23	0.60	0.71	0.60	0.71	0.60	0.71
1999	1.0	1.0	1.0	1.0	1.0	1.0	0.22	0.40	0.16	0.28	0.13	0.23	0.60	0.71	0.60	0.71	0.60	0.71
2000	1.0	1.0	1.0	1.0	1.0	1.0	0.22	0.40	0.16	0.28	0.13	0.23	0.60	0.71	0.60	0.71	0.60	0.71
2001	1.0	1.0	1.0	1.0	1.0	1.0	0.22	0.40	0.16	0.28	0.13	0.23	0.60	0.71	0.60	0.71	0.60	0.71
2002	1.0	1.0	1.0	1.0	1.0	1.0	0.22	0.40	0.16	0.28	0.13	0.23	0.60	0.71	0.60	0.71	0.60	0.71
2003	1.0	1.0	1.0	1.0	1.0	1.0	0.22	0.40	0.16	0.28	0.13	0.23	0.60	0.71	0.60	0.71	0.60	0.71
2004	1.0	1.0	1.0	1.0	1.0	1.0	0.22	0.40	0.16	0.28	0.13	0.23	0.60	0.71	0.60	0.71	0.60	0.71
2005	1.0	1.0	1.0	1.0	1.0	1.0	0.22	0.40	0.16	0.28	0.13	0.23	0.60	0.71	0.60	0.71	0.60	0.71
2006	1.0	1.0	1.0	1.0	1.0	1.0	0.22	0.40	0.16	0.28	0.13	0.23	0.60	0.71	0.60	0.71	0.60	0.71
2007	1.0	1.0	1.0	1.0	1.0	1.0	0.22	0.40	0.16	0.28	0.13	0.23	0.60	0.71	0.60	0.71	0.60	0.71
2008	1.0	1.0	1.0	1.0	1.0	1.0	0.22	0.40	0.16	0.28	0.13	0.23	0.60	0.71	0.60	0.71	0.60	0.71